Systems Engineering Process

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- Federal regulations for ITS projects
- Overview of systems engineering (SE)
- Application of SE process to projects
- FDOT policy/procedural requirements for use of SE
- Roles and responsibilities of stakeholders
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Federal Regulations (FHWA)

23 CFR 940.11 “Project Implementation” requires:

a) All ITS projects funded with highway trust funds shall be based on a systems engineering analysis.

b) The analysis should be on a scale commensurate with the project scope.

ITS project (per 23 CFR 940.3) means any project that **in whole or in part** funds the acquisition of technologies (or systems of technologies) that provide or significantly contribute to the provision of one or more ITS user services as defined in the National ITS Architecture.

23 CFR 940.11(c) Defines Seven Minimum "systems engineering analysis" Items

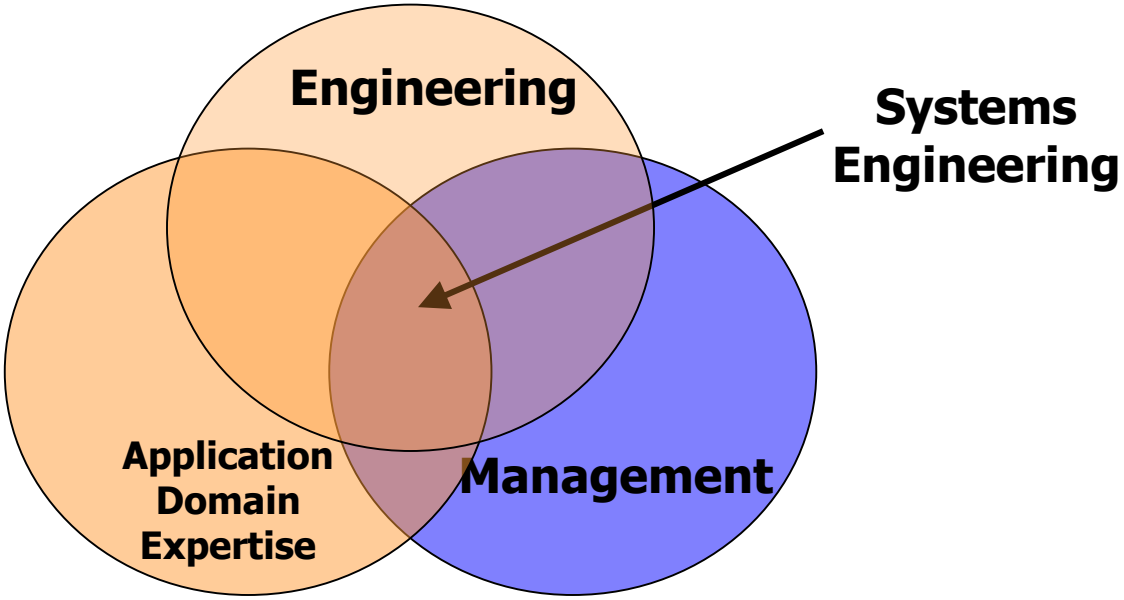
1. Regional ITS architecture
2. Stakeholders' roles and responsibilities
3. Requirements
4. Alternative system configurations and technology
5. Procurement
6. ITS standards and testing
7. Operations and management of the system

23 CFR 940.13 "Project Administration"

- Prior to authorization of highway trust funds for construction or implementation of ITS projects, compliance with §940.11 shall be demonstrated.
- Compliance will be monitored under Federal-aid oversight procedures.
  - Each FHWA Division Office works with state and local partners to establish these procedures.

What is Systems Engineering (SE)?

An ***inter-disciplinary approach*** and means to enable the realization of successful systems… A ***structured process*** for arriving at a final design of a system.



Terminology

System: A combination of interacting elements organized to achieve one or more stated purposes.

Source: INCOSE

What are the SE Principles?

- Start with your eye on the finish line
- Involve stakeholders
- Define the problem before implementing the solution
- Delay technology choices
- Divide and conquer
- Connect the dots - traceability

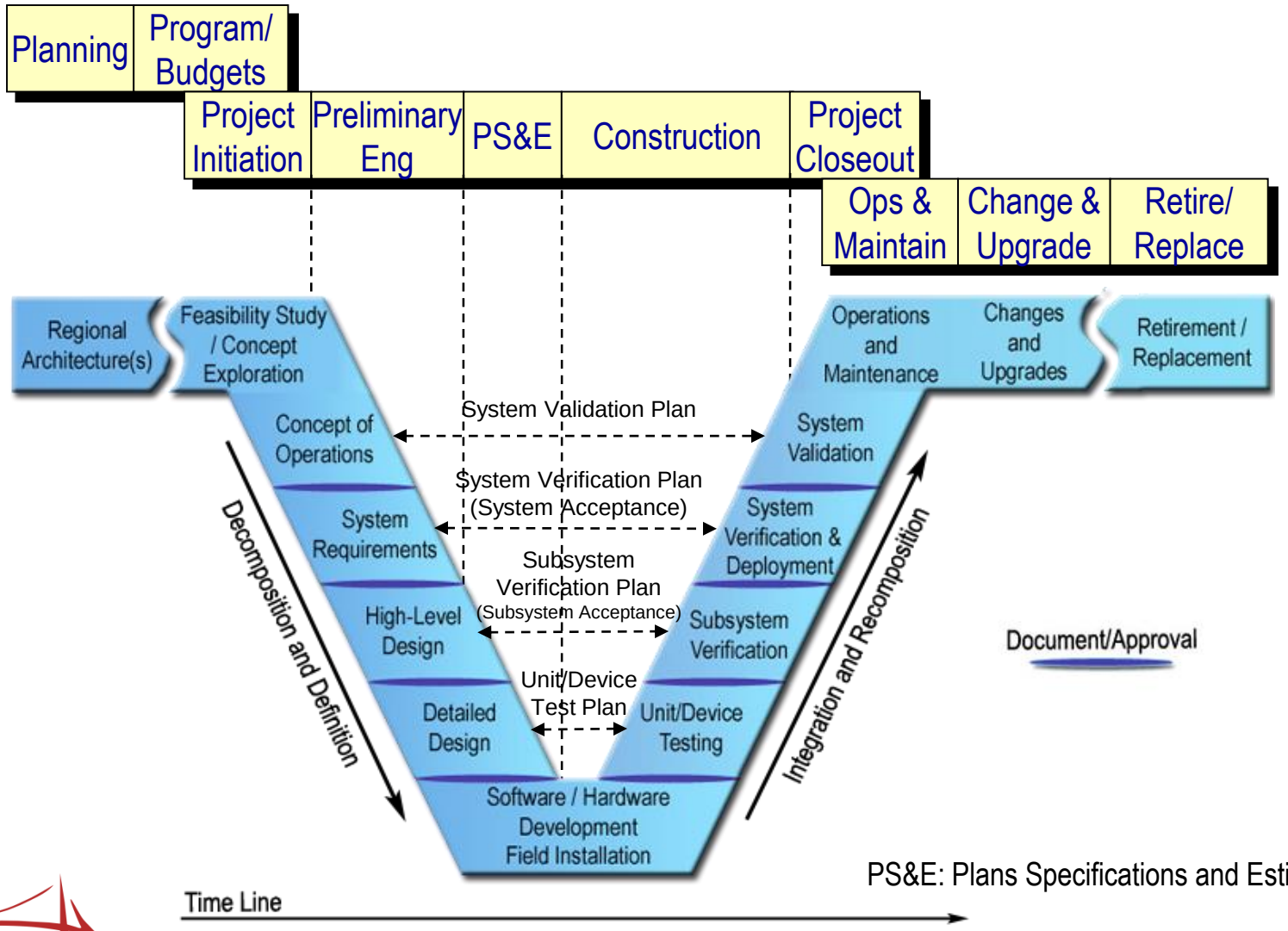
Source: Systems Engineering for ITS - An Introduction for Transportation Professionals (FHWA)

What are the Benefits of Using SE?

- Reduced risk of schedule and cost overruns
- Users' needs met
- Improved stakeholder participation
- More adaptable and resilient systems
- Verified functionality and fewer defects
- Higher level of reuse from one project to the next
- Better documentation

Source: Systems Engineering for ITS - An Introduction for Transportation Professionals (FHWA)

Traditional Road Project Process and the SE "V"



PS&E: Plans Specifications and Estimates

Source: Systems Engineering for ITS - An Introduction for Transportation Professionals (FHWA)

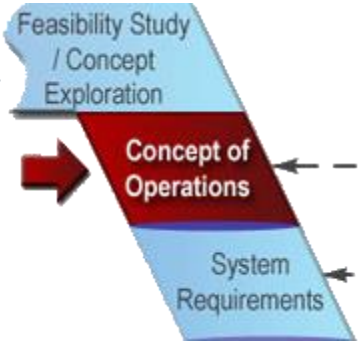
Using the Regional ITS Architecture

- Key activities:
  - Identify relevant regional ITS architecture(s)
  - Identify portions of regional ITS architecture that the project will implement
  - Verify project is consistent with regional ITS architecture
  - Identify any necessary changes to regional ITS architecture

1. Identification of portions of the regional ITS architecture being implemented

Source: Systems Engineering for ITS - An Introduction for Transportation Professionals (FHWA)

Concept of Operations

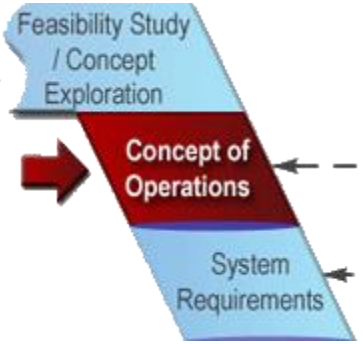


- The ConOps defines:
  - Who: Stakeholder roles and responsibilities
  - What: Stakeholder needs, system elements and high-level capabilities
  - Where: Geographic and physical extent
  - When: Sequence of activities performed
  - How: Development, operations, and maintenance of the system

2. Identification of participating agencies roles and responsibilities

Source: Systems Engineering for ITS - An Introduction for Transportation Professionals (FHWA)

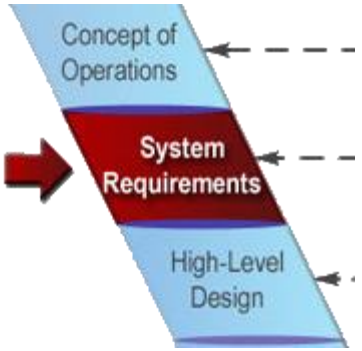
Concept of Operations (Cont.)



- Key activities:
  - Identify stakeholders
  - Define core group responsible for creating ConOps
  - Develop initial ConOps, review with broader stakeholder group and iterate
  - Define stakeholder needs
  - Create a System Validation Plan

Source: Systems Engineering for ITS - An Introduction for Transportation Professionals (FHWA)

System Requirements



- Key activities:
  - ➢ Elicit, analyze, document, validate and manage Requirements
  - ✓ Create a System Verification Plan that assures testing, demonstration, inspection, and analysis in relation to each requirement
  - ✓ Create a System Acceptance Plan that describes the functionality the system must display prior to customer acceptance

3. Requirements definitions

Source: Systems Engineering for ITS - An Introduction for Transportation Professionals (FHWA)

How is SE Applied to a Project?

- Project Systems Engineering Management Plan (PSEMP):
  - Documents how the technical development will be managed and what needs to be documented
  - Details how the SE process will be tailored and development will be conducted
  - Explains how the process activities will be brought together

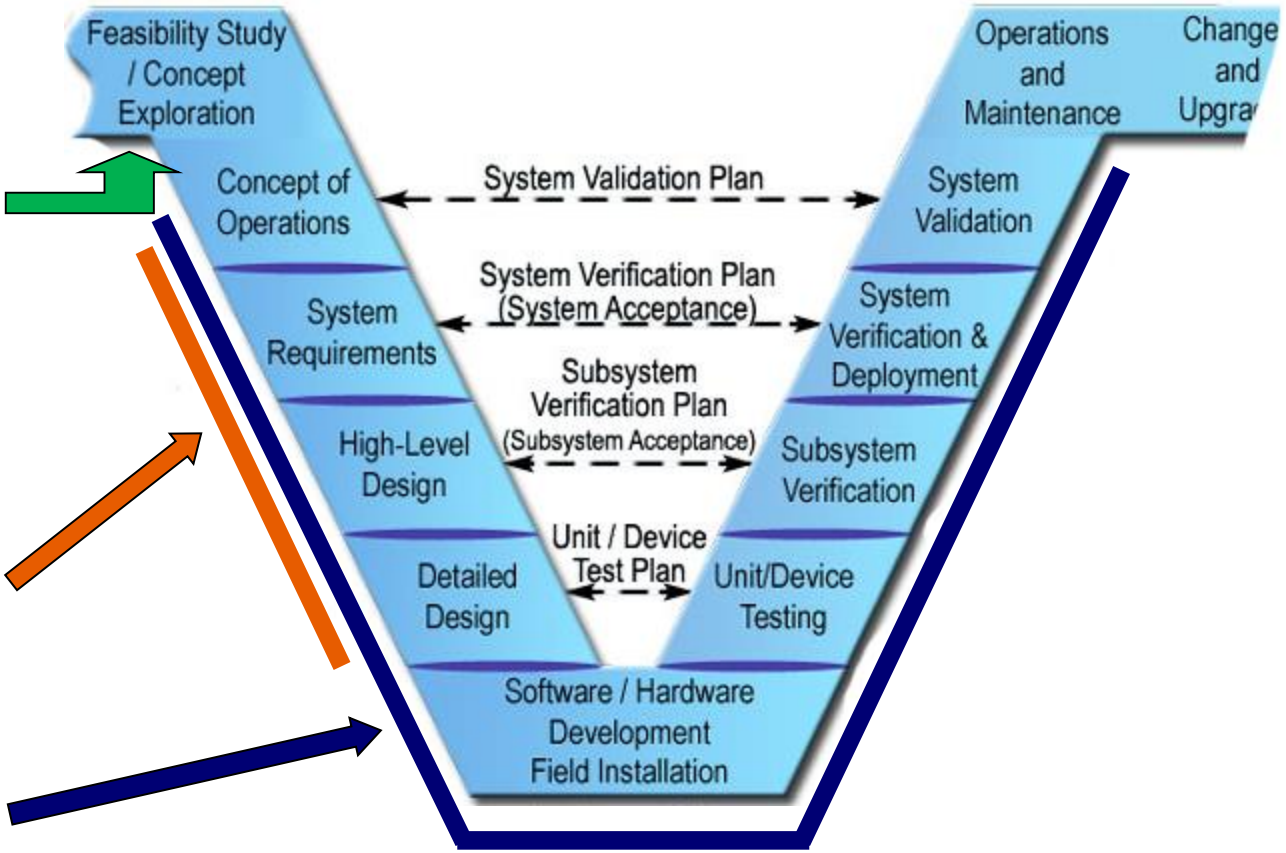
Source: Systems Engineering for ITS - An Introduction for Transportation Professionals (FHWA)

How is SE Applied to a Project? (Cont.)

SEMP milestones formalized between agency and contractor(s)

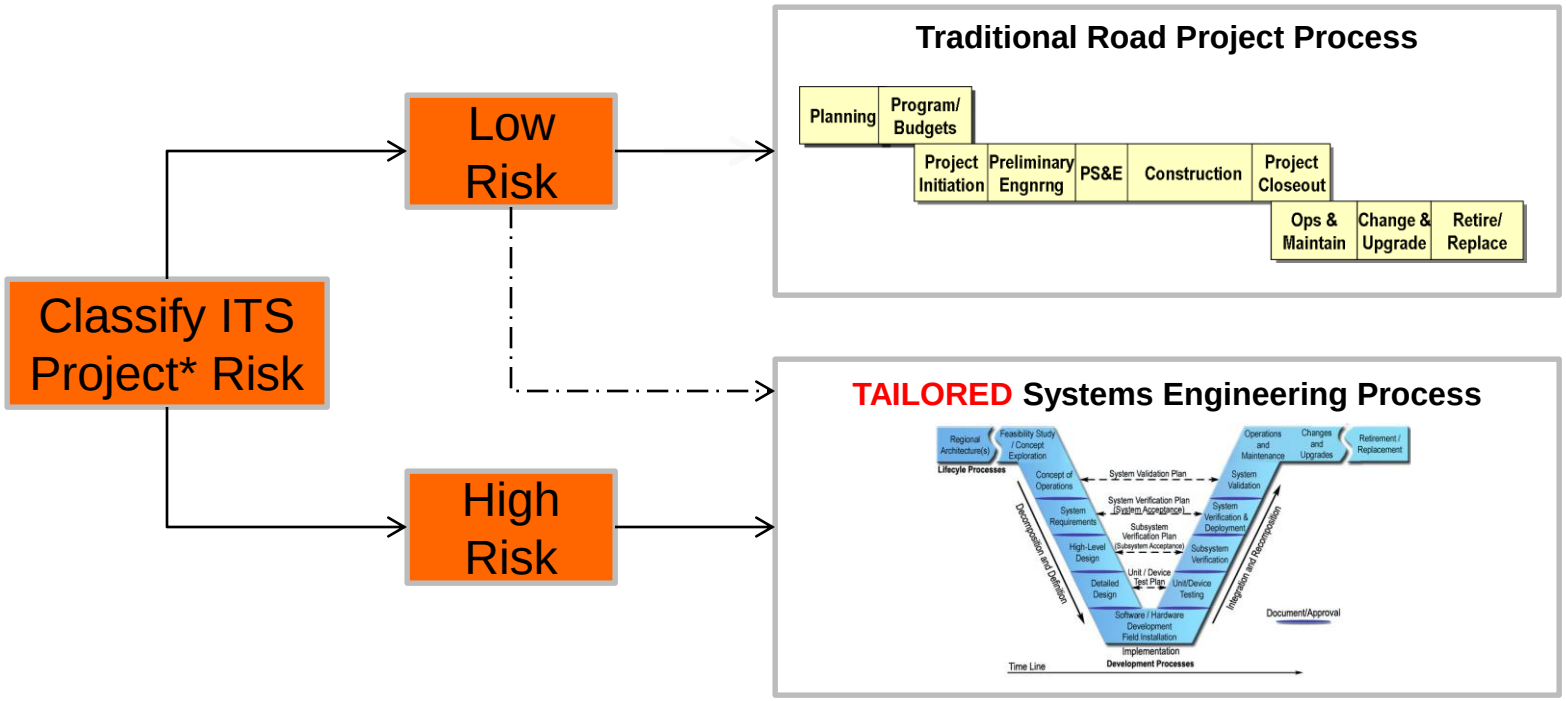
SEMP plans developed, delivered, and approved

SEMP plans used during project implementation



FDOT Policy/Procedure for SE

Systems Engineering and ITS Architecture Procedure (FDOT ID# 750-040-003-c) requires:



* Project funded with highway trust funds and project risk evaluated for ITS component(s) ONLY

FDOT Policy/Procedure for SE (Cont.)

Required for all ITS projects funded with highway trust funds to classify risk

Risk Assessment Form

Submittal Date: _____

Agency: _____

Agency Project Manager: _____

Project Description: _____

Questions:	Yes	No
1. Will the project depend on only your agency to implement and operate?	☐	☐
2. Will the project use only software proven elsewhere, with no new software writing?	☐	☐
3. Will the project use only hardware and communications proven elsewhere?	☐	☐
4. Will the project use only existing interfaces (no new interfaces to other systems)?	☐	☐
5. Will the project use only existing system requirements that are defined in writing?	☐	☐
6. Will the project use only existing operating procedures that are defined in writing?	☐	☐
7. Will the project use only technologies with service life longer than 2.4 years?	☐	☐

FDOT Policy/Procedure for SE (Co...

Notes:

1. If you are unsure about a question, be conservative.
2. If all yes selected, then it is a low-risk project. If there is even one "No" selected", it is a high-risk project.
3. Use Table 1: Risk assessment for Intelligent Tansportation System (ITS) Projects within the document for additional details regarding each question.

Seven Project Risk Attributes

	Low-Risk Attributes
1	Single jurisdiction and single transportation mode (highway, transit or rail)
2	No software creation; uses COTS or proven software
3	Proven COTS hardware and communications technology
4	No new interfaces
5	System requirements fully detailed in writing
6	Operating procedures fully detailed in writing
7	None of the technologies used are near end of service life

COTS: Commercial off-the-shelf

Seven Project Risk Attributes (Cont.)

	High-Risk Attributes
1	Multi-jurisdictional or multi-modal
2	Custom software development required
3	Hardware or communications technology “cutting edge” or not in common use
4	New interfaces to other systems required
5	System requirements not detailed or not fully documented
6	Operating procedures not detailed or not fully documented
7	Some technologies included near end of service life

FDOT Policy/Procedure for SE (Cont.)

Required for all ITS projects funded with highway trust funds using SE process

Florida ITS Project Checklist

Submittal Date: _____

Agency: _____

Agency Project Manager: _____

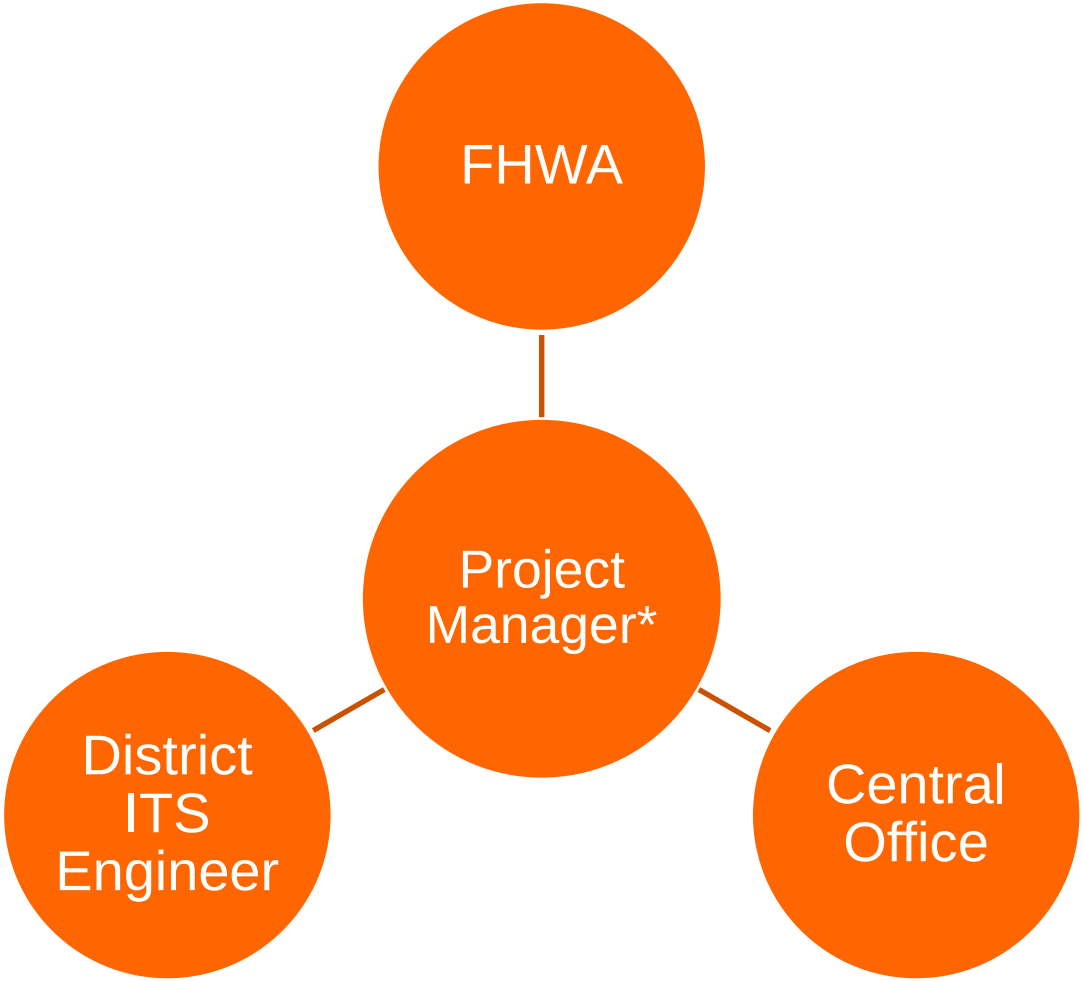
Project Description: _____

Criteria / Question	Yes/No/ Partially	Comments
1. Architecture Scope and Region Description		
a) Is the project in the Regional Intelligent Transportation System (ITS) Architecture?		
b) List the physical subsystems that are included.		
2. Key Agency / Provider Identification		
a) Identify all participating agencies and providers of services, and define their roles.		
b) Where will the system be used and who will be responsible for operations? Maintenance?		
3. Agreements		
a) Are there any agreements that must be implemented between users/agencies in order to implement the project?		
b) Can existing agreements be used?		
4. Concept of Operations (ConOps)		
a) Has a project ConOps been described		

Thirteen Items of the Florida ITS Project Checklist

1. Architecture scope and region
2. Key agency providers
3. Agreements
4. Concept of operations
5. Requirements
6. Interfaces/information flows
7. Analysis of alternatives
8. Procurement options
9. Schedule
10. Standards
11. Maintenance and operations plan
12. Acceptance test plan
13. Configuration management plan

Stakeholders Identified in FDOT Policy / Procedure for SE



* with FDOT District or Local Agency

Roles and Responsibilities for ITS Projects Funded with Highway Trust Funds and FHWA Oversight

Role	Action
Project Manager (PM)	❑ Complete Risk Assessment Form ❑ Perform SE analysis per 23 CFR 940 ❑ Complete Florida ITS Project Checklist[1] ❑ Develop tailored PSEMP[1] ❑ Coordinate extent of oversight with District ITS Engineer and FHWA ❑ Submit all documentation to FHWA and Central Office

[1] if SE process is used

Roles and Responsibilities for ITS Projects Funded with Highway Trust Funds and FHWA Oversight (Cont.)

Role	Action
District ITS Engineer	❑ Provide assistance to PM for ensuring compliance with FDOT policy/procedure
FHWA	❑ Review and approve documentation (for FHWA oversight projects ONLY)
Central Office	❑ Provide clarification on FDOT policy/procedure for use on projects

Project Example

- A new state road is proposed for construction in Florida. The project will also include deployment of six CCTV cameras. It will be partially funded with highway trust funds and cameras will require new interfaces to other systems. The project manager is from the Construction Office.
- What would you do as a project manager?

Project Example (Cont.)

- Does the project meet the federal definition of an ITS project? Yes
- Is it funded with highway trust funds? Yes
- Does 23 CFR 940 apply? Yes
- Is it a high or low risk project? High risk
- Why is it a high risk project? New interfaces
- Who is responsible for developing the SE documentation? Project manager
- Which SE documentation needs to be developed?

Future Steps

- Outreach and coordination of document updates through multiple offices

Document Title	Document Owner
Project Management Handbook	Production Support Office
Local Agency Program Manual	Production Support Office
Project Development and Environment Manual	Environmental Management Office
Construction Project Administration Manual	Construction Office

Resources

Statewide and Regional ITS Architectures:

http://www.dot.state.fl.us/trafficoperations/ITS/Projects_Arch/SITSA.shtm

Systems Engineering and ITS Architecture Procedure (750-040-003-c):

http://www.dot.state.fl.us/proceduraldocuments/procedures.shtm

Project SEMP Template, Risk Assessment Form and Florida ITS Project Checklist:

http://www.dot.state.fl.us/trafficoperations/its/Projects_Deploy/SEMP.shtm

Systems Engineering for ITS – An Introduction for Transportation Professionals (FHWA):

http://ops.fhwa.dot.gov/publications/seitsguide/seguide.pdf

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QUESTIONS AND ANSWERS